

## Introduction to Mathematical Modelling (I002891)

**Course size** *(nominal values; actual values may depend on programme)*

**Credits 6.0**

**Study time 180 h**

**Course offerings in academic year 2024-2025**

A (semester 2)

English

Gent

**Lecturers in academic year 2024-2025**

Van Liedekerke, Paul

LA26

lecturer-in-charge

**Offered in the following programmes in 2024-2025**

[Master of Science in Pharmaceutical Engineering](#)

**crdts**

6

**offering**

A

### Teaching languages

English

### Keywords

Calculus, differential equations, uncertainty quantification, dynamic system analysis

### Position of the course

This course provides a basis for the formulation and usage of mathematical models necessary for simulations of pharmaceutical processes. These models heavily draw on differential equations and concepts from calculus.

In the first part the students are acquainted with basic mathematical techniques and methods that are required to understand, analyse and describe various production processes. Such a mathematical background is needed in preparation for building and simulation of process models. Subsequently, students are familiarized with systems of differential equations and (non-)linear differential equations, and introduced to analytical and numerical solution methods to be able to predict processes

In the second part of the course, students will learn how to deal with modeling uncertainty and probability.

In the third part, the students will learn how to perform a sensitivity analysis and parameter estimation of the models, as well as how to decide how "good" a model is.

### Contents

1. Functions of one variable: continuity, derivatives, Taylor series, Integration
2. Linearization of functions, root finding
4. Vectors and Matrices, eigenvalues, singular value decomposition
5. Functions of several variables: derivatives, Taylor series, gradient, Hessian
7. Introduction to differential equations
8. Qualitative analysis of 1st order diff eqns
9. Solving 1st order diff eqns numerically
10. Systems of diff eqns and higher order diff eqns
11. Laplace transformations
12. Mass balance equations and diffusion effects
13. Probabilistic modeling and stochastic simulations
14. Sensitivity analysis
15. Parameter estimation, Model evaluation, Model selection

### Initial competences

Knowledge of basic mathematics : derivatives, integrals, matrix algebra, vectors. Basic knowledge of Python programming language is highly recommended.

### Final competences

- 1 To understand the mathematical and geometric meaning of functions of one and more variables

- 2 To understand the mathematical and geometric meaning of polar coordinates, parametric functions, vector functions and vector fields.
- 3 To be able to use functions of multiple variables, polar coordinates, parametric functions, vector functions and vector fields
- 4 To build, follow and execute correct reasoning for functions of one and more variables.
- 5 To be able to work with functions of one and more variables in a correct and mathematically precise manner.
- 6 To be able to recognise diverse types of differential equations.
- 7 To be able to apply analytical solution techniques.
- 8 To be able to execute qualitative analyses of (sets of) differential equations.
  
- 9 To be able to use numerical solution methods for differential equations in python.
- 10 To be able to translate a system description into a mathematical model as a set of differential equations
- 11 Be able to make the link between model results and physical reality.
  
- 12 Quantify and compare the sensitivity of model attributes.
- 13 Conduct a parameter estimation and quantify its reliability.

#### **Conditions for credit contract**

Access to this course unit via a credit contract is determined after successful competences assessment

#### **Conditions for exam contract**

This course unit cannot be taken via an exam contract

#### **Teaching methods**

Seminar, Lecture, Independent work

#### **Extra information on the teaching methods**

Theory in plenary lectures, exercises in PC-practicals

#### **Study material**

None

#### **References**

**Adams, R.A. and Essex, C. Calculus 9th edition (2009). Pearson**

P. Vanrolleghem & D. Dochain Bioprocess Model Identification. In: Advanced Instrumentation, Data Interpretation and Control of Biotechnological Processes. Eds. Van Impe J., Vanrolleghem P., Iserentant D., Kluwer (1998).

B.A. Ogunnaike & W.H. Ray Process Dynamics, Modeling and Control. Oxford University Press (1994). L. Ljung System Identification - Theory for the User. Prentice-Hall (1999).

Trench, W.F., Elementary differential equations, Brooks/Cole Thomson Learning, 2001; Boyce, W.E., DiPrima, R.C., Meade, D.B., Elementary Differential Equations and Boundary Value Problems, Wiley, 2017.

#### **Course content-related study coaching**

Study coaching is offered before and after each of the oral lectures and practicum or after appointment. There is also a forum on Ufora

#### **Assessment moments**

end-of-term assessment

#### **Examination methods in case of periodic assessment during the first examination period**

Written assessment with multiple-choice questions, Written assessment

#### **Examination methods in case of periodic assessment during the second examination period**

Written assessment with multiple-choice questions, Written assessment

#### **Examination methods in case of permanent assessment**

Presentation, Assignment

#### **Possibilities of retake in case of permanent assessment**

examination during the second examination period is not possible

#### **Extra information on the examination methods**

--- Klik om te editeren ---

Open book exam  
solving problems on computer

**Calculation of the examination mark**

Periodic evaluation (exam) 70% - Permanent evaluation 30%  
There is no second chance for the permanent evaluation.